

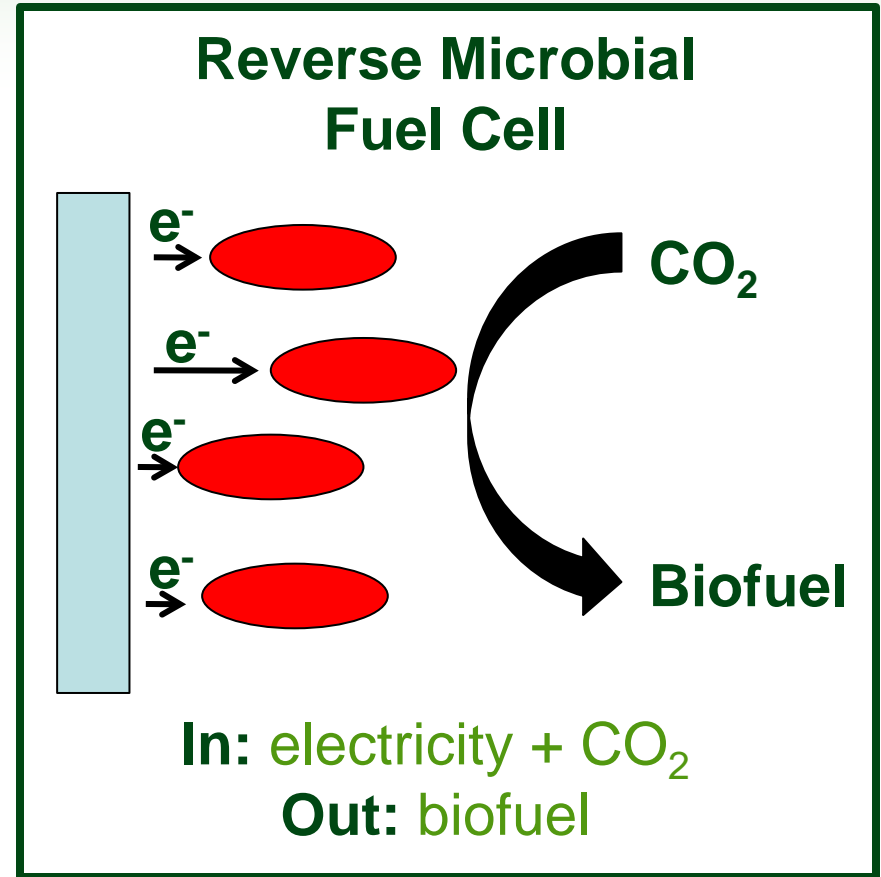
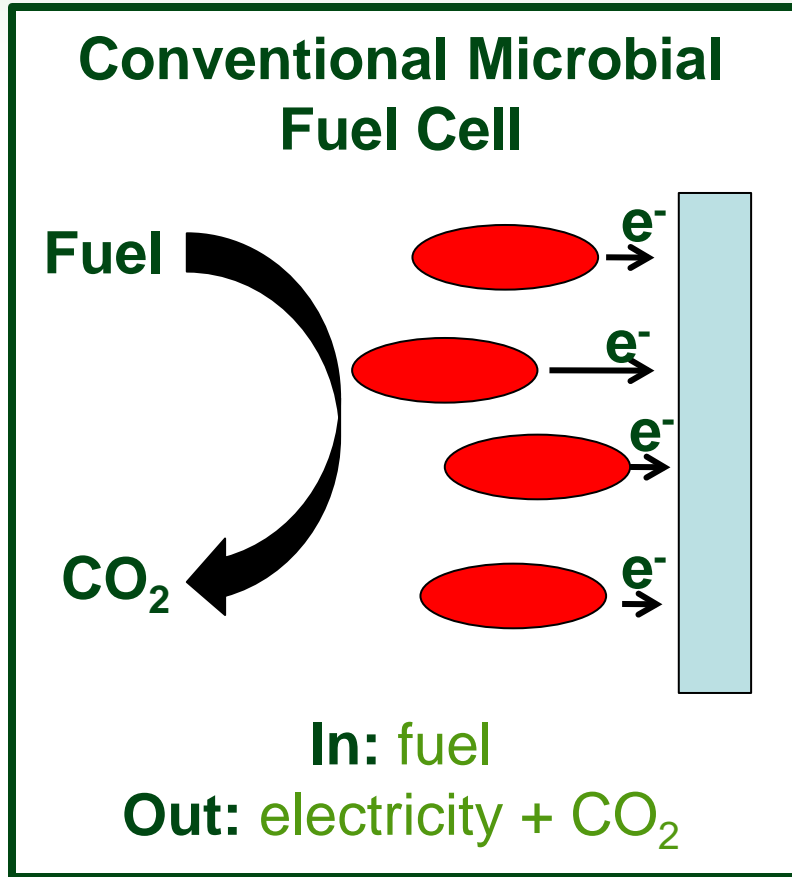
Biofuels from CO₂ Using Ammonia-Oxidizing Bacteria In a Reverse Microbial Fuel Cell

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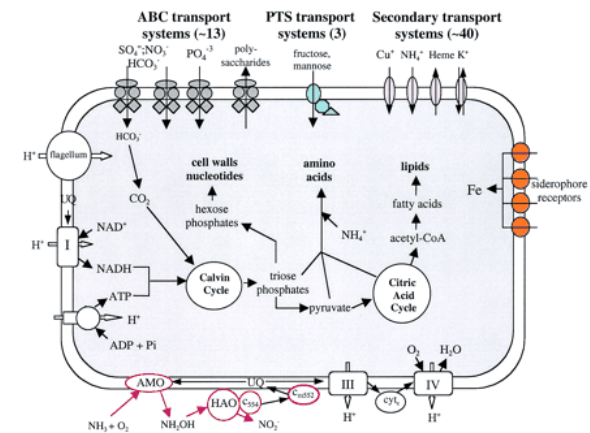
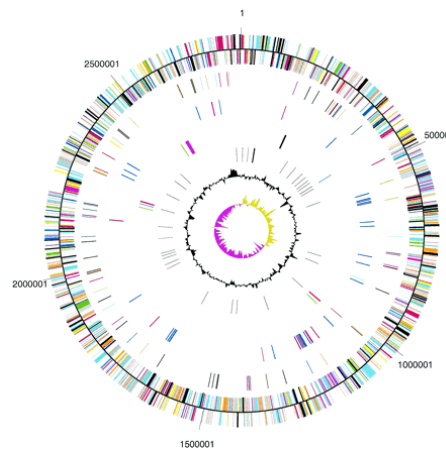
Conventional and Reverse Microbial Fuel Cells (MFCs)



Critical innovation need is the **Electron Mediator**

Ammonia Oxidizing Bacteria

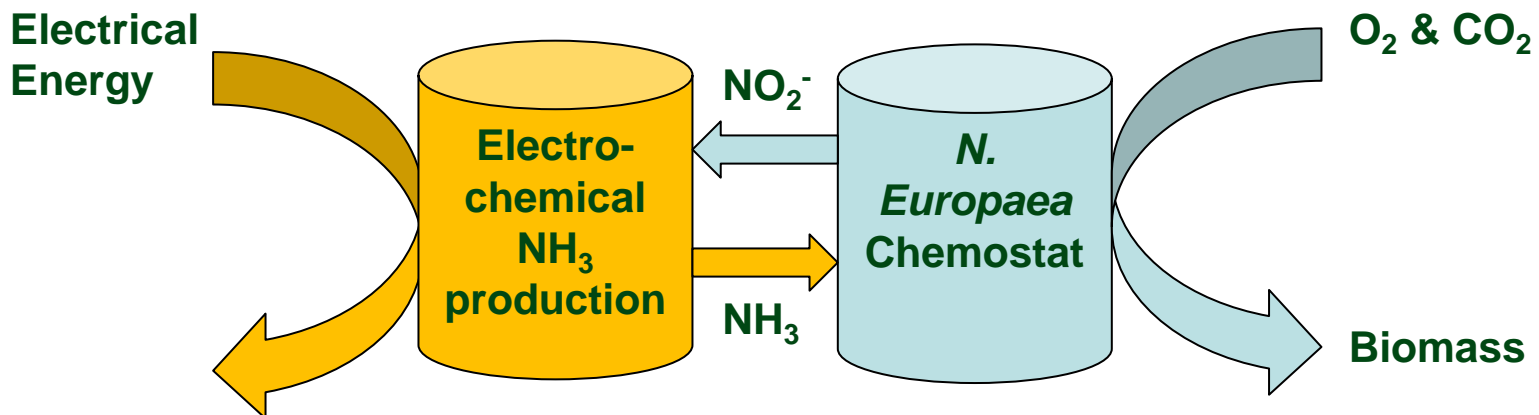
- *Nitrosomonas europaea* are chemolithoautotrophic ammonia-oxidizing-bacteria that are found in wastewater treatment operations
- They fix CO_2 while oxidizing ammonia to nitrite
- The DOE has already sequenced the *N. europaea* genome



Chain et al., *J Bacteriol*, 2003

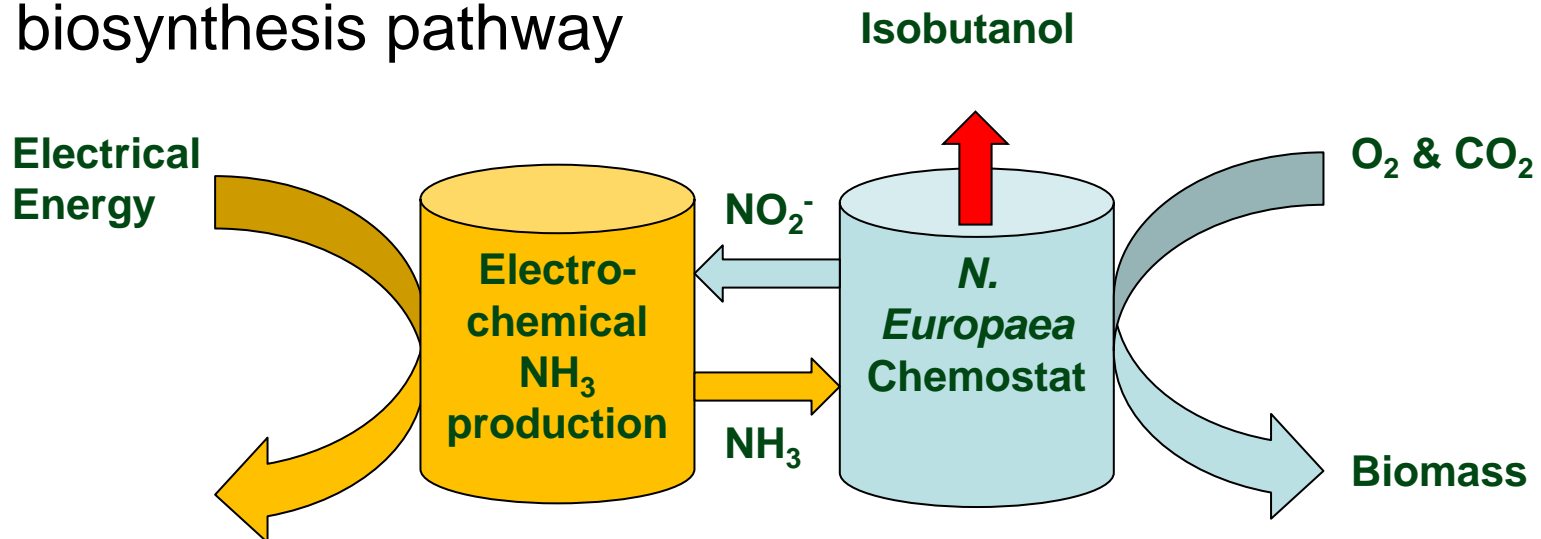
Ammonia as a Redox Mediator

- We are using ammonia as a redox mediator in a reverse microbial fuel cell
- Cells are planktonic – they do not need to contact the electrode – 3D liquid cultures
- Nitrite can be electrochemically reduced back to ammonia
- *N. europaea* can be grown on electricity and air



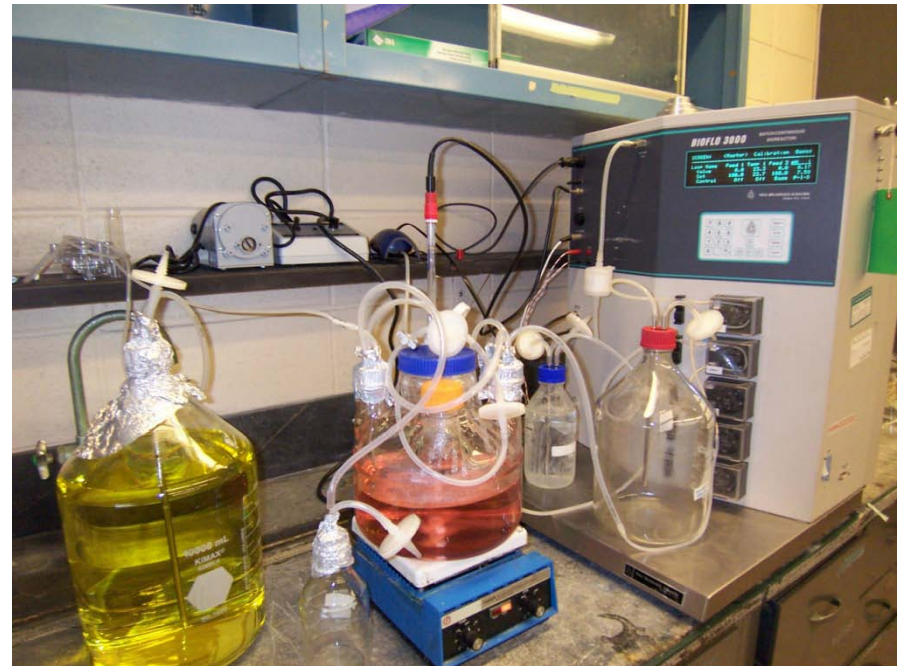
Metabolic Engineering

- This platform can be modified for biofuel production
- Metabolic engineering has been used to create new organisms that produce isobutanol and other higher alcohols using 2-keto acids
- We will add the metabolic pathway to *N. europaea* to enable them to generate isobutanol through the valine biosynthesis pathway



Microbiology Results

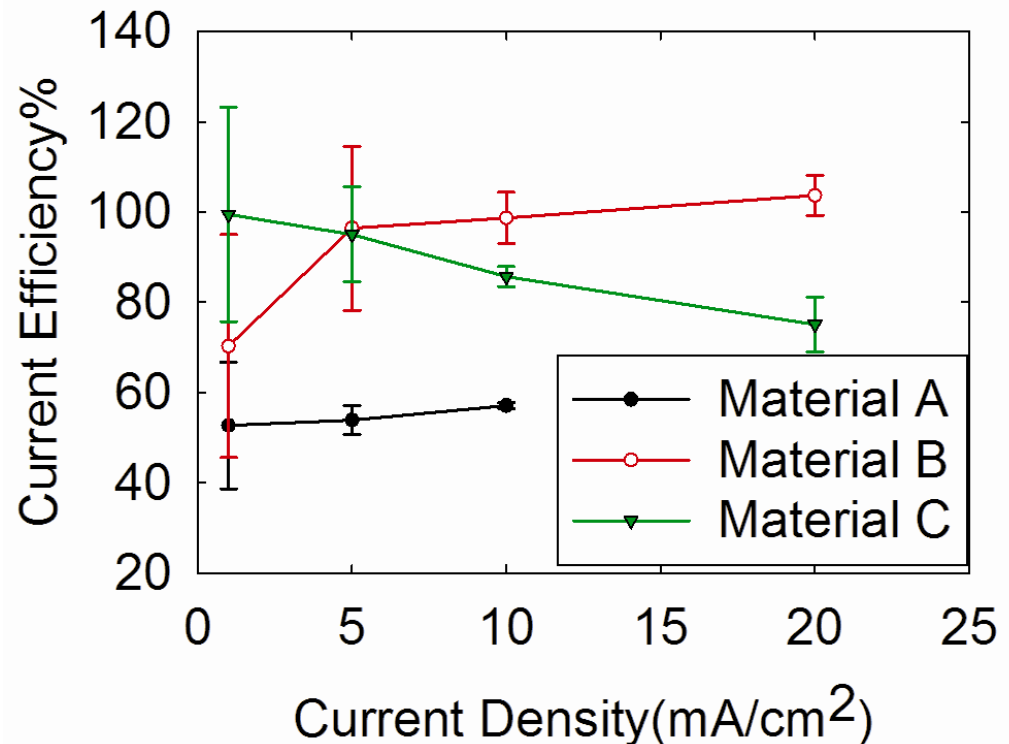
- *N. europaea* cells are tolerant of high ammonia and high nitrite concentrations
- Cells are not impacted by electrochemical reduction of media
- Genetic modification of *N. europaea* cells for isobutanol production currently is underway



Electrochemical Results

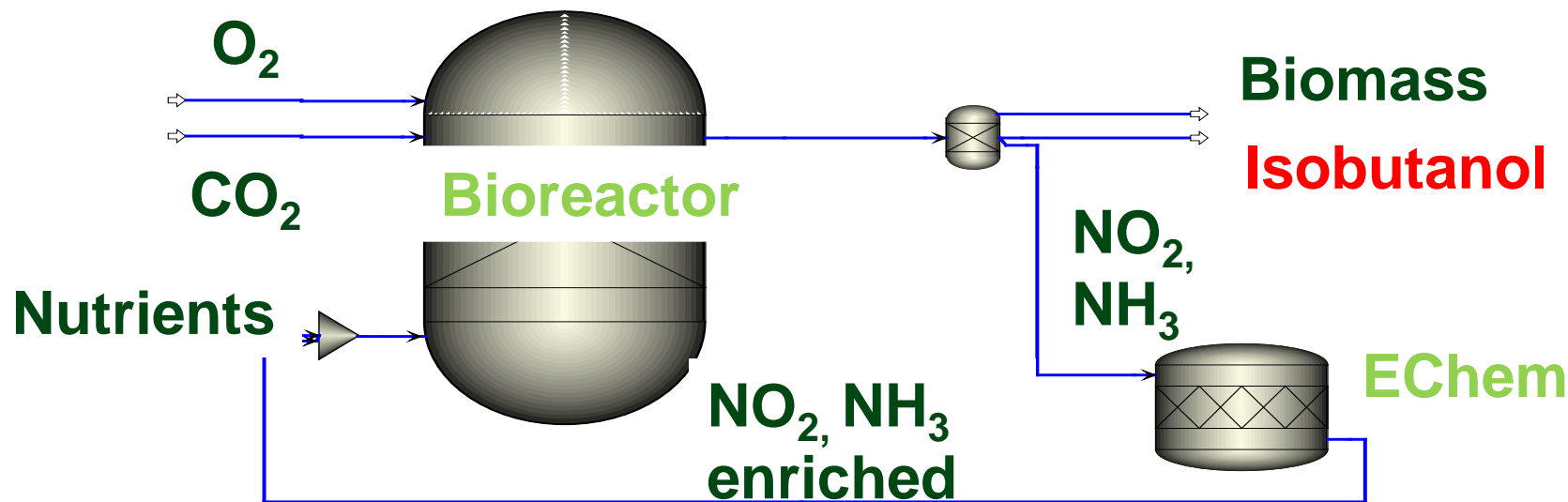
- Various electrode materials and operating conditions have been explored
- An electrochemical reactor has been designed and built
- Very high current efficiencies can be achieved for the reduction of nitrite to ammonia

Current Efficiency for Different Electrode Materials



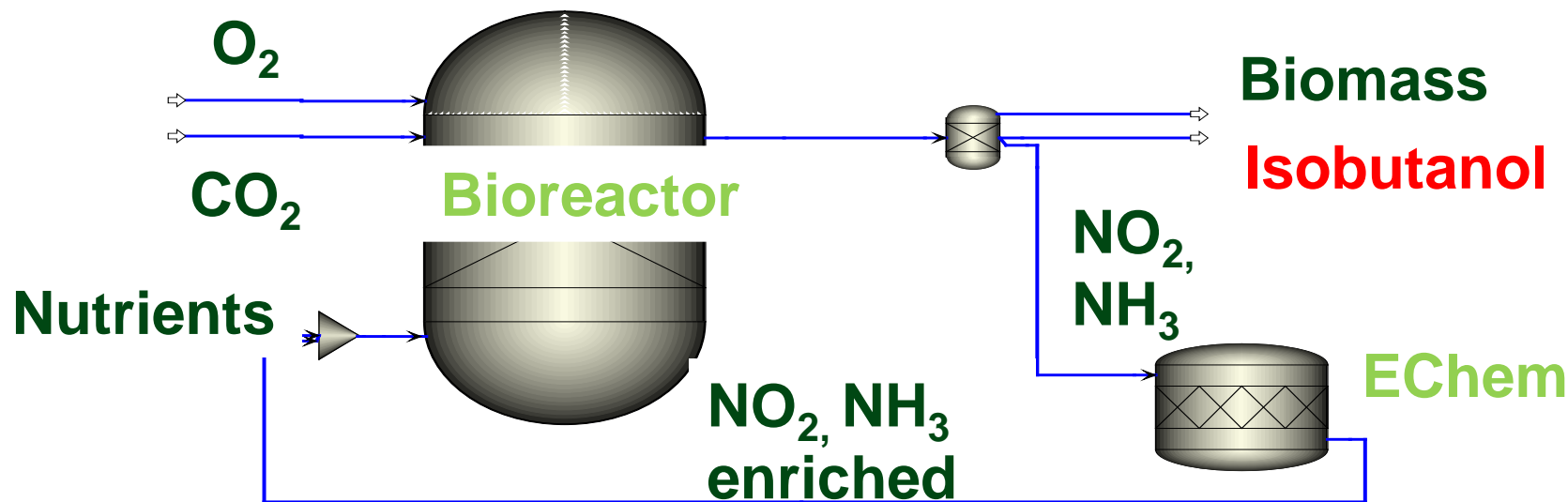
Process Development

- Cost of isobutanol will depend strongly on cost of electricity – Electrochemical process may be operated when electricity is cheapest
- Ammonia can also be supplemented from wastewater treatment operations



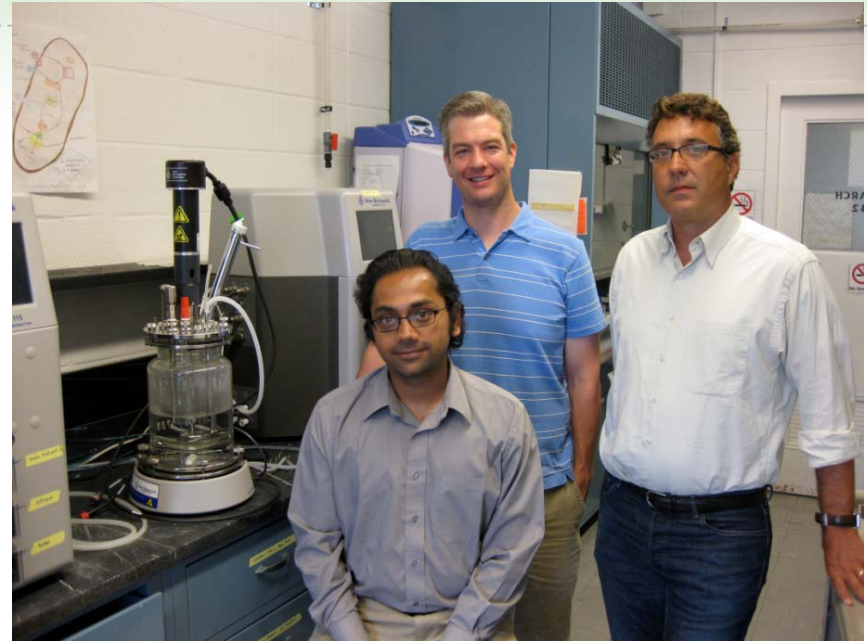
Process Development

- Wastewater treatment and electrochemical remediation of nitrate have already been scaled-up and practiced on the industrial scale
- Other pathways can be introduced into *N. europaea* to create other biofuels and chemicals



Columbia ARPA-E Team

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- Graduate Students
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 - Prof. Michael Hill
 - Columbia University Senior Design Team



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